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PREDICTIVE CONTROL OF LOCAL SOAP PRODUCTION

Olagunju, Mukaila
Department of Computer Science, Kwara State Polytechnic, Ilorin, Nigeria.
E-mail: olamukaila@yahoo.com

ABSTRACT
This paper predicts the proportion of Palm Kernel Oil (P.K.O) and sodium hydroxide for the production of local soap popularly known as Soda. The local soap (Soda) has been reported over the years to cause body bleaching because the local manufacturer are ignorant of correct mixing ratio of sodium hydroxide (NaOH) and Palm Kernel Oil (P.K.O). The local soap under study was put into test by controlling the rate of production $\frac{dy}{dx}$ in terms of mixing ratio. The Runge-Kutta model of fourth order was employed for the predictions with the aid of Matlab R2007a. The two reactants, palm oil and sodium hydroxide were denoted as x and y respectively. The results showed the proportions of x and y for the exact amount of soap and the residues after reactions inform of errors.

KEYWORDS: Predictive, Control, Local Soap, Reactants and Production.

INTRODUCTION
Production process control is an essential part of production and operations management, and operations improvement can be facilitated through effective controlling of the production process. Effective process control enables operation managers to intervene in the production system for controlling various forms of variance occurring in the process (Jaikumar, 1988). Inadequate process control causes the production system to produce the defective goods. A production process can be affected by assignable causes, also refers to as “contingent events” one of the key issues related with the process control is to determine when to intervene in the production process in order to prevent or minimize the negative effect that can be caused by those contingent events. In the literature process, control is also perceived as related to a more comprehensive function in operations management, i.e. inventory control management. Hall (1983), suggested that the inventory level is an indication of the efficiency of process control. This relationship between inventory and efficient process control has been further investigated in hall (1987), Jaikumar (1988), Karmarkar (1987), and more recently function of Statistical Process Control (SPC) theory have developed several economic rules to intervene into the production process to minimize the costs due to out-of-control process and also defective products it produce (Chiu, 1975, 1976; Chiu and Cheung, 1977; Chiu Wetherill, 1974; Costa, 1993; Duncan, 1956,1971; Gibra, 1978; Goel and Wu, 1973; Nelson, 1993; Taylor, 1968). Ho and Case (1994) presents a more comprehensive literature review on the economic design of control charts. A typical SPC model would suggest an economic rule taking into account an assignable cause, in-control versus out-control state, false alarm (e.g. a defective product from an in-control process) versus true alarm signaling occurrence of a contingent event, and probabilistic distributions of processing time and event time. Markov decision theory has been used in some of the economic models: based on principles of dynamic program and Bayesian theory, a Markov decision model capitalizes on a sequential updating in determining the process state (Bertsekas, 1987; Dreyfus and Law, 1977; Ross, 1970 and 1983).

Control according to (Frank, 1966) is the fundamental engineering and managerial function whose major purpose is to measure, evaluate and adjust the operation of a process or machine or system under a dynamic condition in order to achieved desire objectives in production process.

The objectives of establishing any production unit of any manufacturing company is to manufacture products that provide the level of functionality and quality demanded by customers, while keeping the production cost to minimum and maximize the profit. To achieve this, it is essential to efficiently control the management items such as materials process and resources that are indispensable to any manufacturing operation. The increase availability of computers made the automation of model development possible in other to control the process of production in any production company.

MATERIALS AND METHODS

The materials used in local soap (soda) production are Palm oil and sodium hydroxide (NaOH). The local soap (soda) production involves the following steps:

Step 1: Pouring of palm oil into a rubber container
Step 2: Add sodium hydroxide to palm oil
Step 3: Mix sodium hydroxide to oil proportion

MATHEMATICAL MODEL DEVELOPMENT

The following assumptions were made in the model development:
The principle of conservation of mass and energy is obeyed i.e Input = Output + accumulated + disappearance.
The Total volume of the reactants is change
The Volume of sodium hydroxide and palm oil keep on changing
Reactions are of first order.

Mathematical model is a mathematical description of quantitative properties of an expression (Jan and Miroslay, 2007). In this paper, the mathematical model development was based solely on the thermodynamic law which says that the rate at which certain product is produced is directly proportional to the mixture of concentration of the reactants taking part in the reaction process, when and only when the other factors such as temperature and pressure remain constant under any favourable condition. In this study, the law of thermodynamic was related to the saponification reaction which takes place in soap production in order to determine the rate at which one reactant is related to another reactant by differential equation.

$$\frac{dy}{dx} \alpha \; f(y,x) \qquad \text{Eq 1}$$

Where

x is the concentration of palm oil
y is the concentration of sodium hydroxide taken part in the reaction.

From Eq 1

$$\frac{dy}{dx} = kf(y, x) \qquad \text{Eq 2}$$

Since the reaction is of first order, k is equal to one and equation 2 can be re-written as

$$\frac{dy}{dx} = f(y,x) \qquad \text{Eq 3}$$

Equation 3 can be related to Runge-Kutta of fourth order model as

$$\frac{dy}{dx} = (y_o + h * (k_1 + 2k_2 + 2k_3 + k_4)$$

Where

$k_1 = f(y, x)$
$k_2 = f(x + {}^{h}/_{2}, y + h * k_1)$
$k_3 = f(x + {}^{h}/_{2}, y + h * k_2)$
$k_4 = f(x + h, y + h * k_3)$
eq. 4

Exact (g) can be calculated as:
Esp. (-x) + 2 x X – 2
Eq. 5
And error = abs (g) – y
g is the exact

Where y_o is the initial volume of Sodium Hydroxide
x_o is the initial volume of palm oil
h is the interval step by which reaction is taken place.
The Runge-Kutta of fourth order model above was used for the predictions of palm oil and sodium hydroxide proportions for the production of local soap with the aid of Matlab R2007a.

RESULTS AND DISCUSSION

The results are showed in outputs 1 to 5. Output 1 showed the results for the command rk_4 ('f3',0,20,40,5,4). In this command, x ranges from 0.0gm-20gm, initial value of y = 40gm. At x = 0.0gm, no chemical reaction takes place. The value of x was varied from 0.0gm to 20gm insteps of 4gm, the corresponding values of y were recorded for the exact and the residues (error) for the four reactions k1, k2, k3 and k4 for five different iterations. As the values of x increases, the corresponding values of y also increases and the higher the exact amount of local soap produced. The errors for each mixing proportions were also determined. In all the outputs (1-5), it was discovered that the level of production of local soap (soda) is controlled by the concentration at which the two reactants take part in the production process. It was also discovered that when the production did not take place, the rate of reactions remain constant. It was noticed that the error can only be recorded when the production take place. The higher the production, the higher the rate at which the reactions take place, the more errors recorded.

Computer Output,

OUTPUT 1
rk-4 ('f3',0,20,40,5,4)
Kutta Method of Fouth order

Table1; Oil represented by x jn gms with sodium hydroxide represented y grams to produced exact and error

0.0	....	....	....	x(gm) k1 k2	40.000	40.000	0.00
4.00	40.00	122.00	286.00	1188.00	1402.67	6.0	1.40e+003
8.00	1406.67	4222.00	9852.67	40821.33	48320.89	14.00	4.83e+004
12.00	48328.89	144988.67	338308.22	1401565.78	1659313.19	22.00	1.66e+006
16.00	1659325.19	4977977.56	11615282.30	48120458.37	56970182.02	30.00	5.70e+007
20.00	56970198.02	170910596.07	398791392.17	1652135770.72	1955976812.18	38.00	1.96e+009

OUTPUT 2
rk_4('f3',20,40,80,5,4)
Runge Kutta Method of Fouth order

Table 2; Oil represented by x jn grms with sodium hydroxide represented y grams to produced exact and error

X(gm)	K1	K2	K3	K4	Y(gm)	Exact	error
20.00	.....	…..	….	…..	80.000	80.000	0.00
24.00	100.00	302.00	706.00	2928.00	3442.67	46.00	3.40e+003
28.00	3466.67	10402.00	24272.67	100561.33	119027.56	54.00	1.19e+005
32.0	119055.56	357168.67	833394.89	3452639.11	4087575.41	62.00	4.09e+006
36.00	4087607.41	12262824.22	28613257.85	118540642.81	140341184.99	70.00	1.40e+008
40.00	140341220.99	421023664.96	982388552.91	4069895436.64	4818381913.91	78.00	4.82e+009

OUTPUT 3
rk_4('f3',0,20,40,5,4)
Runge Kutta Method of Fouth order

Table 3; Oil represented by x jn gms with sodium hydroxide represented y grams to produced exact and error

X(grm)	K1	K2	K3	K4	y(grm)	Exact	error
0.00	…..	…..	…..	…..	40.000	40.000	0.00
4.00	40.00	122.00	286.00	1188.00	1402.67	6.0	1.40e+003
8.00	1406.67	4222.00	9852.67	40821.33	48320.89	14.00	4.83e+004
12.00	48328.89	144988.67	338308.22	1401565.78	1659313.19	22.00	1.66e+006
16.00	1659325.19	4977977.56	11615282.30	48120458.37	56970182.02	30.00	5.70e+007
20.00	56970198.02	170910596.07	398791392.17	1652135770.72	1955976812.18	38.00	1.96e+009

OUTPUT 4
rk_4('f3',20,40,80,5,4)
Rungr Kutta Method of Fouth order

Table 4; Oil represented by x jn gms with sodium hydroxide represented y grams to produced exact and error

X(grm)	K1	K2	K3	K4	Y(grm)	Exact	error
20.00	…..	……	……	……	80.000	80.000	0.00
24.00	100.00	302.00	706.00	2928.00	3442.67	46.00	3.40e+003
28.00	3466.67	10402.00	24272.67	100561.33	119027.56	54.00	1.19e+005
32.00	11905.56	357168.67	833394.89	3452639.11	4087575.41	62.00	4.09e+006
36.00	4087607.41	12262824.22	28613257.85	118540642.81	140341184.99	70.00	1.40e+008
40.00	140341220.99	421023664.96	982388552.91	4069895436.64	4818381913.91	78.00	4.82e+009

Output 5
rk_4('f3',40,60,100,5,4)
Runge Kutta Method of Fouth order

Table 5; Oil represented by x jn gms with sodium hydroxide represented y grams to produced exact and error

X(gm)	k1	K2	K3	K4	y(gm)	Exact	error
40.00	….	…..	…..	……	100.000	100.000	0.00
48.00	4840.00	14522.00	33886.00	140.388.00	166158.67	94.00	1.66e+005
52.00	166206.67	498622.00	1163452.67	4820021.33	5706410.22	102.00	5.71e+006
56.00	5706462.22	17119388.67	39945241.56	165487432.44	195921846.6		
60.00	195921902.96	587765710.89	1371453326.74	5681735213.93	6726651975.06	118.00	6.73e+009

CONCLUSION

The predictions for the proportions of Palm Kernel Oil (P.K.O) and sodium hydroxide (NaOH) for the production of local soap popularly known as Soda based on Runge-Kutta model of fourth order with the aid of Matlab R2007a have been presented. The exact amount of local soap (soda) and the residues (errors) to be produced after the reactions for different iterative processes under consideration were also reported.

RECOMMENDATION

The followings are recommended:

The mixing ratio of x and y must be adequately controlled to avoid bleaching and other dangerous effects on the body.

Adequate experiments must take place before the production of local soap (soda).

Adequate amount of reactants must be used to avoid sub-standard of local soap (soda) production.

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